

Stabilization Procedures to Mitigate Edge Rutting for Granular Shoulders – Phase II

tech transfer summary

January 2011

RESEARCH PROJECT TITLE

Stabilization Procedures to Mitigate Edge Rutting for Granular Shoulders – Phase II

SPONSORS

Iowa Highway Research Board
(IHRB Project TR-591)
Iowa Department of Transportation
(InTrans Project 08-319)

PRINCIPAL INVESTIGATOR

Charles T. Jahren
Associate Professor, Civil, Construction
& Environmental Engineering
Iowa State University
515-294-3829
cjahren@iastate.edu

CO-PRINCIPAL INVESTIGATOR

David J. White
Associate Professor, Civil, Construction
& Environmental Engineering
Iowa State University
515-294-1892
djwhite@iastate.edu

MORE INFORMATION

www.intrans.iastate.edu

CMAT

Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103

The Construction Management and Technology (CMAT) Program is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the CMAT Program is to improve the efficiency and cost-effectiveness of planning, designing, constructing, and operating transportation facilities through innovative construction processes and technologies.

The sponsors of this research are not responsible for the accuracy of the information presented herein. The conclusions expressed in this publication are not necessarily those of the sponsors.

Edge ruts in granular road shoulders are an important and persistent safety issue that are challenging to remedy.

Objectives

- Develop a series of strategies for mitigating edge rut problems using various mixtures and gradations of granular materials and various stabilization agents.
- Rate the performance of a subset of the above-mentioned strategies by constructing and observing test sections.
- Recommend strategies based on the results of test section performance.
- Assist the Iowa Department of Transportation (DOT) in implementing the use of the recommended strategies.

Problem Statement

Several conditions coincide to cause edge ruts in granular shoulders. Air movements (generated by traffic) blow fine particles away from the pavement edges, which would otherwise serve as binders to hold the shoulder materials together and resist rutting. When vehicles go off-track and drop off the edge of the pavement, they displace the larger, remaining particles.

The drainage from the pavement surface is concentrated at the edge, softening the shoulder materials, and exacerbating the displacement process. The deeper binding materials that haven't been blown away are compacted by off-tracking vehicles into a hard crust one to three inches below the pavement edge.



Shoulder drop off along the pavement edge on Highway 18

When a shallow wedge of unbound material is replaced near the pavement edge, it is quickly displaced, because it doesn't have the stability that comes from being knitted into the underlying materials.

Research Description

A multifaceted investigation was undertaken to develop recommendations for methods to stabilize granular road shoulders with the goal of mitigating edge ruts. The research investigation included:

- Reconnaissance of problematic shoulder locations,
- A laboratory study to develop a method to test for changes in granular material stability using stabilizing agents,
- Construction and observation of three sets of test sections under traffic at locations with problematic granular shoulders.

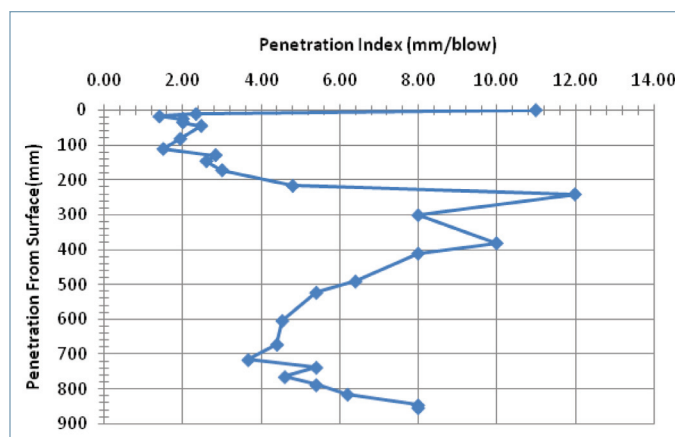
Research began with a list of 29 problematic shoulder sections throughout Iowa DOT District 2, as documented by DOT maintenance personnel.

A field investigation was conducted throughout District 2 to document the conditions at these problematic sections. The investigation included conducting dynamic cone penetrometer (DCP) tests, collecting samples of the shoulder aggregate, and taking elevation profiles and site photos.

Using the DCP field data, California Bearing Ratio (CBR) plots of the problematic shoulders were developed for each location. Elevation profile data from each location was plotted to illustrate the shoulder's elevation progressing away from the pavement's edge. For each location, the results of laboratory testing for grain size and Atterberg limits were summarized.

Several stabilizing agents were considered and used in constructing the test sections for this study:

- Calcium chloride
- Base One®
- Magnesium chloride
- DUSTLOCK®



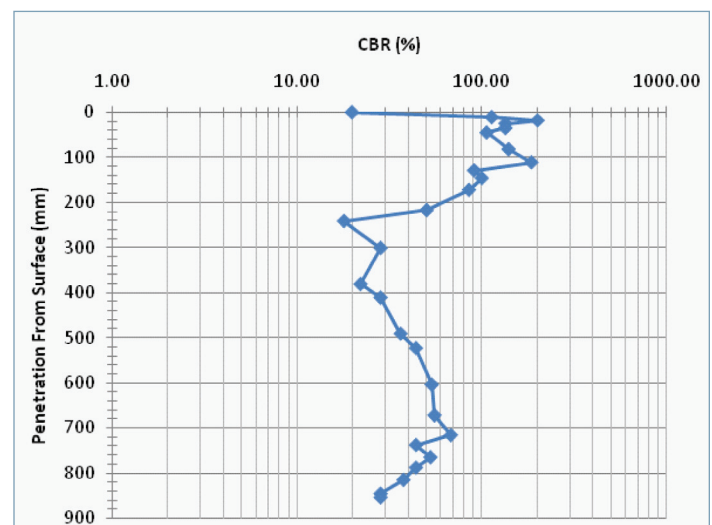
DCP test results



Spraying calcium chloride on shoulder surface



Spraying DUSTLOCK on Test Section V



CBR measurements

Calcium chloride and magnesium chloride are applied as liquid salt solutions that suppress dust and stabilize by retaining moisture. Base One is a liquefied silica and soda ash emulsion that binds and stiffens certain soils and granular materials. DUSTLOCK is a trade name for a soybean soapstock and it was used because maintenance personnel in District 2 had a previous positive experience using the same product applied to the shoulder of US 18 near Garner on July 25, 2000.

Phase II Test Section Construction Locations

US Hwy	Direction	Vicinity
20	Eastbound	West of Jesup
75	Southbound	North of Sioux Center
20	Westbound	West of Jesup

Key Findings

Conclusions

- Problematic shoulders are generally stiff enough to carry expected traffic loads for emergency pull-off and temporary parking. Material gradations are generally finer than specified for new construction and cross slopes are often steeper than called out on cross sections for new construction. However, such differences in what is expected for original construction are consistent with damage that would be expected during use and maintenance (degradation of size due to breakage and abrasion and loss of material through erosion and winter and summer maintenance).

Therefore, it seems likely that edge ruts develop from a combination of vehicle off-tracking and time elapsed between maintenance cycles, rather than defects regarding original geometry and material gradation or from structural weakness.



Pull-behind compactor takes too much time to safely turn for additional passes

Some effort to renew cross slope and material gradation may be helpful in mitigating edge ruts. In addition, a shorter maintenance cycle would most likely be required to mitigate edge ruts.

- Calcium chloride, magnesium chloride, and Base One did not provide noticeable improvements on the US 20 shoulders. However, they were easily applied and have the potential to be applied with the Iowa DOT's own maintenance staff, using its own equipment that could be modified from winter use.

These methods were attempted because it was hypothesized that an important failure mode was that fine particles near the pavement edge were being removed by wind erosion, leaving only large particles that are easily displaced by off-tracking vehicles.

These products bind fine particles, mechanically with Base One and by attracting moisture with calcium chloride and magnesium chloride. Apparently, some other mechanism causes the edge ruts, despite the presence of fine particles near the pavement edge.

- If full-depth reclamation is used to incorporate stabilizers, the Iowa DOT does not currently own and operate the necessary equipment to compact and stabilize the reclaimed material. To provide the needed compaction effort, heavier equipment would have to be purchased or rented.

In particular, it would be necessary to have a pneumatic compactor that could operate bi-directionally. Typically-available, pull-behind compactors do not allow enough passes to be made quickly enough when consideration is given to the time required to safely turn the units, especially on limited access highways.



Bi-directional compactor allows enough passes to be made quickly enough to compact and stabilize reclaimed material

- DUSTLOCK appears to wear well in locations where the shoulder material provides a stable base and vehicles do not off-track to the extent that they do on the US 20 test section. In areas of heavy off-tracking, preliminary indications are that stabilizing the shoulders reduces the number of maintenance cycles to half of what they would be without the stabilizer.
- The laboratory test method for investigating stabilizer performance appeared to be a reasonable effort that provided some information about stabilized material behavior in confined situations. However, the method would have to be combined with a test similar to an asphalt rut test to detect instability for unconfined circumstances.

Recommendations

- Consider using DUSTLOCK for shoulders with stable material for roads with moderate traffic (about as much as on US 18 near Garner, which is 6,000 to 6,500 Annual Average Daily Traffic/AADT).
- For problematic areas with unstable materials, consider paving 2 to 4 ft strips next to the pavement. It might be possible to develop construction contracts similar to patching contracts to facilitate such improvements. Also, it may be possible to include such an improvement with a patching contract.
- Consider experimenting further with the topical applications calcium chloride and magnesium chloride to moisten shoulder material, so it is easier to grade and compact properly in dry weather.
- Continue the use of geogrid and flyash where necessary to stabilize soft subgrades beneath the shoulder material (in situations where such soft subgrades are problematic).
- Consider experimenting further with Base One where shoulder stiffness is insufficient.
- Limit scarification to light scarification that is only slightly deeper than edge ruts that are being repaired.
- Consider greater use of bi-directional rollers when shoulder repairs and maintenance require heavy compaction. The Iowa DOT's current self-propelled pneumatic rollers will likely be satisfactory for many such applications.
- Consider the development of lightly-paved shoulders for areas beyond rumble strips. Consider providing deep, lightly-bound bases using various stabilizing agents.
- Consider increasing the frequency of adding new shoulder material in areas with steep cross slopes and overly fine gradations of existing granular shoulder material.
- Consider developing methods to redistribute shoulder material from areas that have low cross slope to areas that have high cross slope. Such a system might include laser scanning or Light Detection and Ranging (LiDAR) to establish the location of materials, and trimming equipment to strike off areas with low cross slope.

Implementation Benefits

Efforts to eliminate edge ruts are important for several reasons. Granular shoulders with rutting and drop-off may contribute to drivers losing control and running off the road. Possible results are property damage, injuries, and/or fatalities.



DUSTLOCK performance on stable granular shoulder material



DUSTLOCK performance on unstable granular shoulder material